

Claims

- [c1] A method for forming a strained $\text{Si}_{1-y} \text{Ge}_y$ layer above an insulator layer, the method comprising the steps of:
- forming a relaxed $\text{Si}_{1-x} \text{Ge}_x$ layer on a first crystalline semiconductor substrate;
- forming a strained $\text{Si}_{1-y} \text{Ge}_y$ layer on said relaxed $\text{Si}_{1-x} \text{Ge}_x$ layer;
- forming a $\text{Si}_{1-z} \text{Ge}_z$ layer on said strained $\text{Si}_{1-y} \text{Ge}_y$ layer;
- forming a hydrogen-rich defective layer in said relaxed $\text{Si}_{1-x} \text{Ge}_x$ layer;
- providing a second crystalline semiconductor substrate having an insulator layer thereover;
- bonding a top surface of said $\text{Si}_{1-z} \text{Ge}_z$ layer on said first substrate to said insulator layer on said second substrate;
- separating said relaxed $\text{Si}_{1-x} \text{Ge}_x$ layer at said hydrogen-rich defective layer to form a structure comprising said second substrate with said insulator layer, said $\text{Si}_{1-z} \text{Ge}_z$ layer on said insulator layer, said strained $\text{Si}_{1-y} \text{Ge}_y$ layer on said $\text{Si}_{1-z} \text{Ge}_z$ layer, and a portion of said relaxed $\text{Si}_{1-x} \text{Ge}_x$ layer on said strained $\text{Si}_{1-y} \text{Ge}_y$ layer; and
- removing said portion of said relaxed $\text{Si}_{1-x} \text{Ge}_x$ layer.

- [c2] The method of Claim 1, wherein said first crystalline semiconductor substrate comprises a material selected from the group consisting of Si, SiGe, SiGeC and SiC.
- [c3] The method of Claim 1, wherein said relaxed $\text{Si}_{1-x}\text{Ge}_x$ layer is formed by a method comprising the steps of:
 - growing a graded layer of SiGe;
 - growing a constant concentration layer of SiGe on said graded layer of SiGe; and
 - smoothing said constant concentration layer of SiGe using chemical mechanical polishing.
- [c4] The method of Claim 1, wherein said relaxed $\text{Si}_{1-x}\text{Ge}_x$ layer is formed by a method comprising the steps of:
 - growing a layer of SiGe;
 - implanting He into the substrate with said layer of SiGe;
 - and
 - annealing said layer of SiGe.
- [c5] The method of Claim 1, wherein said relaxed $\text{Si}_{1-x}\text{Ge}_x$ layer has a Ge concentration x of about 0.05 to about 1.0.
- [c6] The method of Claim 5, wherein said relaxed $\text{Si}_{1-x}\text{Ge}_x$ layer has a Ge concentration x of about 0.15 to about 0.40.
- [c7] The method of Claim 1, wherein said strained $\text{Si}_{1-y}\text{Ge}_y$

layer is grown epitaxially on said relaxed $\text{Si}_{1-x}\text{Ge}_x$ layer.

- [c8] The method of Claim 1, wherein said strained $\text{Si}_{1-y}\text{Ge}_y$ layer has a Ge concentration y of 0 to 0.05.
- [c9] The method of Claim 8, wherein said strained $\text{Si}_{1-y}\text{Ge}_y$ layer has a Ge concentration y of 0.
- [c10] The method of Claim 1, wherein said Ge concentration y is less than said Ge concentration x.
- [c11] The method of Claim 1, wherein said $\text{Si}_{1-z}\text{Ge}_z$ layer is grown epitaxially on said strained $\text{Si}_{1-y}\text{Ge}_y$ layer.
- [c12] The method of Claim 1, wherein said $\text{Si}_{1-z}\text{Ge}_z$ layer has a Ge concentration z of about 0.05 to about 1.0
- [c13] The method of Claim 12, wherein said $\text{Si}_{1-z}\text{Ge}_z$ layer has a Ge concentration z of about 0.10 to about 0.30.
- [c14] The method of Claim 1, wherein said hydrogen-rich defective layer is formed by implanting hydrogen ions into said relaxed $\text{Si}_{1-x}\text{Ge}_x$ layer.
- [c15] The method of Claim 1, wherein said second crystalline semiconductor substrate comprises a material selected from the group consisting of single-crystal silicon, polysilicon, SiGe and GaAs.
- [c16] The method of Claim 1, wherein said insulator layer

comprises a material selected from the group consisting of silicon oxide, silicon nitride, aluminum oxide, silicon oxynitride, hafnium oxide, zirconium oxide and doped aluminum oxide.

- [c17] The method of Claim 1, further comprising, prior to said bonding step, the step of polishing the top surface of said $\text{Si}_{1-z}\text{Ge}_z$ layer.
- [c18] The method of Claim 1, wherein said top surface of said $\text{Si}_{1-z}\text{Ge}_z$ layer is bonded to said insulator layer by a method comprising the step of:
annealing at a temperature of about 50 °C to about 500 °C, for a time period of about 2 hours to about 50 hours.
- [c19] The method of Claim 1, wherein said relaxed $\text{Si}_{1-x}\text{Ge}_x$ layer at said hydrogen-rich defective layer is separated by a method comprising the step of:
annealing at a temperature of about 200 °C to about 600 °C.
- [c20] The method of Claim 1, wherein said portion of said relaxed $\text{Si}_{1-x}\text{Ge}_x$ layer is removed by a method comprising the step of:
etching using hydrogen peroxide, hydrofluoric acid and acetic acid.